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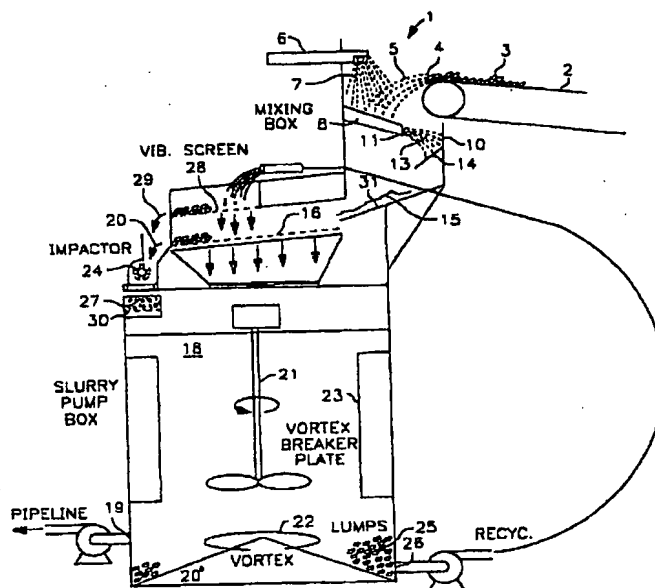
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(54) Titre : CAISSE DE POMPE A BOUE AGITEE POUR L'HYDROTRANSPORT DE SABLE PETROLIFERE

(54) Title: AGITATED SLURRY PUMP BOX FOR OIL SAND HYDROTRANSPORT



(57) Abrégé/Abstract:

A large, mechanically agitated pump box is used between a mixer, for mixing oil sand and water to produce a slurry, and a pipeline for conveying the slurry to a processing facility. Prior to the aqueous slurry being discharged into the pump box from the mixer, it is screened to reject large solids. The oversize is directed to an impactor where it is comminuted and the comminuted product is screened again prior to being discharged into the pump box. The pump box is designed to increase the residence time of the slurry in the pump box and to separate the slurry into two phases, the suspended slurry and the larger lumps that cannot be suspended. The larger lumps that settle in the pump box are recycled to the impactor for comminution.



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1 "AGITATED SLURRY PUMP BOX FOR  
2 OIL SAND HYDROTRANSPORT"

3  
4 ABSTRACT OF THE DISCLOSURE

5 A large, mechanically agitated pump box is used between a mixer, for  
6 mixing oil sand and water to produce a slurry, and a pipeline for conveying the  
7 slurry to a processing facility. Prior to the aqueous slurry being discharged  
8 into the pump box from the mixer, it is screened to reject large solids. The  
9 oversize is directed to an impactor where it is comminuted and the  
10 comminuted product is screened again prior to being discharged into the  
11 pump box. The pump box is designed to increase the residence time of the  
12 slurry in the pump box and to separate the slurry into two phases, the  
13 suspended slurry and the larger lumps that cannot be suspended. The larger  
14 lumps that settle in the pump box are recycled to the impactor for  
15 comminution.

1                                    **FIELD OF THE INVENTION**

2            This invention relates to an assembly and process for forming an  
3    aqueous oil sand slurry, screening it to remove oversize solids, mechanically  
4    agitating it and conditioning it, to produce a slurry ready for pipelining.

5  
6                                    **BACKGROUND OF THE INVENTION**

7            The McMurray oil sands of Alberta constitute one of the largest  
8    deposits of hydrocarbons in the world. The oil sands are first mined at a mine  
9    site and then transported to an extraction plant in order to extract the bitumen.  
10   In recent years the preferred mode of transport of mined oil sands has been  
11   by way of a slurry pipeline. The oil sand is mixed with water to form a slurry  
12   that is capable of being pumped down a pipeline to the extraction plant.

13           One needs to provide a suitable means for slurring the oil sand with  
14   water and entraining air to produce a slurry that is suitable for pumping down  
15   the pipeline. The as-mined oil sand contains a variety of lumps including  
16   rocks, clay and oil sand lumps. Therefore a mixer means is required that not  
17   only slurries the oil sand but also ensures that oversize lumps that are  
18   unsuitable for pumping and feeding into the pipeline are rejected. A typical  
19   aqueous slurry comprises the following: bitumen froth, sand, smaller lumps of  
20   oil sand, clay and/or rocks (between 0 and 2 inches in diameter) and larger  
21   lumps of oil sand, clay and/or rock (between 2 and 4 inches in diameter).

22           In United States patent No. 5039227, issued to Leung et al and  
23   assigned to the owners of the present application, one mixer circuit for this  
24   purpose has been disclosed.

1           In the Leung et al mixer circuit, an oil sand stream is dropped from the  
2 end of a conveyor into a mixer tank. The mixer tank is open-topped, has a  
3 cylindrical body and conical bottom and forms a central bottom outlet. A  
4 swirling vortex of slurry is maintained in the tank and the incoming oil sand  
5 and added water is fed into it. Slurry leaves the tank through the bottom  
6 outlet, is screened using vibrating screens to reject oversize, and is  
7 temporarily collected in an underlying pump box. Some of the slurry in the  
8 pump box is withdrawn and pumped back through a return line to be  
9 introduced tangentially into the mixer tank to form the swirling vortex. The  
10 balance of slurry in the pump box is withdrawn and pumped into the pipeline.

11           In Canadian patent 2,227,667, a second-generation mixer circuit in the  
12 form of a vertically oriented stack of components, functions to slurry the oil  
13 sand with water. The oil sand is initially dropped from the end of a conveyor  
14 and is contacted in mid-air with a stream of water. The mixture drops into a  
15 downwardly slanted trough and the water and oil sand mixes as they move  
16 turbulently through the open-ended trough. The slurry is deflected as it leaves  
17 the trough and is spread in the form of a thin sheet on an apron. It is then fed  
18 over screens to reject oversize lumps. The screened slurry drops into a pump  
19 box where it is temporarily retained. The rejected lumps are comminuted in  
20 an impactor positioned at the end of the screens. The comminuted oil sand is  
21 screened to remove remaining oversize lumps and the screened comminuted  
22 oil sands are delivered into the pump box. The slurry in the pump box is  
23 withdrawn and pumped into the pipeline.

1 Both of the prior art mixer circuits routinely produce a slurry that  
2 contains lumps ranging from 0 to 4 inches in diameter. Before the slurry is  
3 pumped to the pipeline, it is temporarily stored in a pump box. The pump box  
4 is restricted to a certain volume because if the volume of retained slurry is too  
5 great, settling of the sand and lumps will occur. As a result, the residence  
6 time of the slurry in the pump box is relatively short (in the order of 1 minute)  
7 and the slurry is quickly pumped from the pump box to the pipeline.

8 As the slurry travels down the pipeline, slurry conditioning or digestion  
9 takes place. Adequate conditioning is critical for good bitumen recovery in a  
10 downstream separation vessel and is especially important when extracting  
11 bitumen from low grade oil sand. Basically what conditioning means is that  
12 the larger oil sand lumps are ablated into smaller lumps and bitumen flecks  
13 coalesce and coat or attach to air bubbles. The lumps need to be dispersed  
14 in water to promote the release of oil droplets and the attachment of air.  
15 Conditioning also benefits from turbulent pipeline flow and is dependent upon  
16 the length of the pipeline, hence, the length of time that the slurry resides in  
17 the pipeline before reaching the separation vessel. The larger the oil sand  
18 lumps, the more time required to digest or ablate these lumps to release the  
19 bitumen flecks. Therefore if a slurry is routinely produced that contains large  
20 lumps, there will be a need for long pipelines or residence time.

21 An ideal slurry for fast conditioning (*i.e.* under 10 minutes) would be  
22 one that consists of lumps that are less than 2 inches in diameter. But  
23 producing such a slurry is impractical due to limitations of the prior art mixer  
24 circuits. For example, in the second-generation mixer circuit, slurry routinely  
25 contains lumps that are 2 to 4 inches in diameter. This is as a result of

1 limitations in the mixer circuit with respect to the screening process. These  
2 circuits must accommodate large throughputs of oil sand. Therefore, the  
3 screen openings must be considerably larger than 2 inches, hence, larger  
4 lumps (i.e. 2 to 4 inches in diameter) are introduced into the pipeline. This  
5 means that the pipeline has to be a certain length to ensure sufficient  
6 residence time of such a slurry (preferably a minimum of 4 km to give a  
7 residence time of approximately 12 to 15 minutes) for proper conditioning to  
8 occur.

9       There may be times, however, when it is unnecessary to have such a  
10 long pipeline. But if the pipeline is too short, the residence time of the slurry in  
11 the pipeline will be too short for proper conditioning of the slurry to occur.  
12 This will result in a decrease in bitumen recovery. However, a pump box can  
13 be designed whereby the harder to digest 2 to 4 inch lumps are segregated  
14 from the rest of the slurry and are directed to an impactor where they are  
15 comminuted to small lumps. Therefore the length of the pipeline becomes  
16 less critical.

#### 17                   SUMMARY OF THE INVENTION

18       This invention relates to an assembly and process for forming an  
19 aqueous oil sand slurry whereby the slurry contains preferably lumps that are  
20 about 2 inches or less in diameter prior to the slurry being pumped to the  
21 pipeline.

22       In the prior art, a pump box is used to temporarily store the aqueous  
23 slurry prior to being pumped through the pipeline. In the current invention, the  
24 cross-sectional area of the pump box is increased relative to what was  
25 conventional and a mixing means is added to the pump box. This

1 accomplishes two things. First, the slurry is separated into two phases: a  
2 suspended slurry with lumps 2 inches in diameter or less and larger lumps  
3 that cannot be suspended and therefore settle to the bottom of the pump box.  
4 In a preferred feature, the larger lumps that settle to the bottom are pumped  
5 out of the pump box, directed to a 2 inch screen deck and the reject lumps are  
6 comminuted in an impactor. The comminuted product is delivered back to the  
7 pump box. Over time, the overall effect is that the slurry being introduced into  
8 the pipeline contains only lumps that are about 2 inches or less. Hence,  
9 conditioning of the slurry occurs much faster, thereby eliminating the need for  
10 long pipelines for conditioning.

11 Second, the actual residence time of the slurry in the pump box is  
12 increased relative to the prior art due to the fact that the cross-sectional area  
13 of the pump box has been increased relative to the prior art. Therefore, some  
14 conditioning of the slurry will take place in the pump box itself, rather than in  
15 the pipeline. Both the volume of the pump box and the flow rate of the slurry  
16 will determine the residence time of the slurry in the pump box. The following  
17 equation can be used to determine the residence time:

18 
$$\text{volume (m}^3\text{)} / \text{flow rate (m}^3\text{/min)} = \text{residence time (min)}.$$

19 In practice, it is desirable to keep the slurry flow rate relatively constant.  
20 Therefore, the optimal way to increase residence time is to increase the  
21 volume of the pump box. This can be achieved by increasing the cross-  
22 sectional area of the pump box.



1           In one broadly stated aspect of the invention, a process is  
2 provided for producing an aqueous slurry of oil sand, suitable for introduction  
3 into a pipeline, comprising:

- 4           • mixing oil sand and water to form an aqueous slurry containing  
5           lumps;
- 6           • screening the slurry to remove oversize lumps and produce a  
7           screened slurry containing undersize lumps;
- 8           • temporarily retaining the screened slurry in a pump box for a pre-  
9           determined retention time;
- 10          • mechanically agitating the slurry contained in the pump box; and
- 11          • withdrawing slurry from the pump box and pumping it into a  
12          pipeline.

13          In another broadly stated aspect of the invention, a downwardly  
14 sequenced assembly is provided for producing an aqueous slurry of oil sand,  
15 ready for introduction into a pipeline, comprising:

- 16          • means for mixing oil sand with water to produce a slurry containing  
17          lumps;
- 18          • means for screening oversize lumps from the slurry to produce a  
19          screened slurry containing undersize lumps suitable for pumping  
20          through a pipeline; and
- 21          • a pump box for receiving the screened slurry, said pump box having  
22          means for mechanically agitating the slurry within the pump box,  
23          said pump box being associated with a means for withdrawing  
24          slurry from the pump box and pumping it into a pipeline.

1 More specifically, in a preferred form, the downwardly sequenced  
2 assembly for producing an aqueous slurry of oil sand, ready for introduction  
3 into a pipeline, comprises:

- 4 • A conveyor having a discharge end for delivering a continuous  
5 stream of oil sand that falls through air into a trough;
- 6 • A pipe for delivering a stream of water which contacts and wets the  
7 falling oil sand in mid-air;
- 8 • The trough being downwardly slanted, open-topped and positioned  
9 in spaced relation below the conveyor discharge end and the water  
10 pipe. The trough is operative to receive the mixture of oil sand and  
11 water and confine it temporarily to allow the oil sand and water to  
12 turbulently mix and form a slurry stream as they flow along its  
13 length and discharge from its open lower end;
- 14 • An upstanding wall positioned adjacent the trough's lower end and  
15 spaced therefrom so that the slurry stream hits it and is deflected,  
16 with the result that its direction of flow is changed and further mixing  
17 is induced;
- 18 • An apron providing a broad surface for receiving the deflected  
19 stream, whereby the stream is spread out and thinned to form a  
20 slurry sheet adapted to efficiently utilize the screen area;
- 21 • A first screen assembly for receiving and screening the slurry sheet  
22 to reject oversize and produce a screened slurry stream;
- 23 • A pump box for receiving and temporarily retaining the screened  
24 slurry;

- 1       • A mechanical agitator in the pump box for separating the screened  
2       slurry into two phases, the slurry containing suspended lumps and  
3       the larger lumps that cannot be suspended; and
- 4       • A means for withdrawing suspended slurry from the pump box and  
5       delivering the slurry into the pipeline.

6       In a preferred extension of the invention, the rejected oversize lumps  
7       from the first screen assembly are fed directly into an impactor and  
8       comminuted. The comminuted product is screened by a second screen  
9       assembly to reject remaining oversize. The comminuted, screened product is  
10      then delivered into the mechanically agitated pump box.

11      In a second preferred extension of the invention, the mechanically  
12      agitated pump box is equipped with a means for recycling lumps reaching the  
13      bottom of the pump box, preferably by withdrawing them tangentially from the  
14      bottom of the pump box. These lumps are delivered to a third screen which  
15      may be attached to the first screen assembly. The rejected oversize lumps  
16      are then fed directly into the impactor to be comminuted in the impactor. The  
17      comminuted product is then delivered into the mechanically agitated pump  
18      box.

19

## 20                   DESCRIPTION OF THE DRAWINGS

21           Figure 1 is a schematic side view showing the preferred embodiment of  
22      the invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

As-mined oil sand to be pipelined is first crushed before conveying it to a mixer circuit 1. This is commonly done by passing it through a set of double rolls, producing 24-inch product. This pre-treatment (which forms no part of the invention) is done to break down the very large contained lumps.

The crushed oil sand contains lumps of varying size and composition.

The mixer circuit 1 comprises a series of downwardly arranged components.

The uppermost component is a conveyor 2 for continuously delivering a stream of crushed oil sand 3. The oil sand cascades or falls from the discharge end 4 of the conveyor 2 - it drops downwardly through an air space 5.

A horizontal pipe 6 is positioned opposite to the conveyor discharge end 4. The pipe discharges a stream 7 of water into the falling oil sand in mid-air at a sufficient rate so that the water/oil sand ratio is equivalent to that of the pipeline slurry. Typically this ratio is about 1:3 by weight. The stream 7 contacts the downwardly descending oil sand and is distributed through it and wets it.

The oil sand and water drop into a downwardly slanted, open-topped, open-ended trough 8. The trough is formed of plate steel.

As the oil sand and water move through the trough, they mix turbulently and form a slurry.

A solid, vertical wall 10 formed of steel is positioned adjacent the lower end 11 of the trough 8. The wall 10 is spaced from the trough's lower end 11 and extends across the trajectory path of the slurry stream 13 discharging from the trough.

1           A downwardly slanted apron 14 extends downwardly from the wall 10 in  
2   a direction opposite to that of the trough 8.

3           The slurry stream 13 hits the wall 10, is deflected and changes its  
4   direction of movement, being discharged onto an apron 14. In the course of  
5   these movements, further turbulent mixing of the oil sand and water occurs. On  
6   reaching a second apron 31, the slurry spreads out laterally and is thinned, to  
7   form a slurry sheet 15 of comparable width to the screen 16.

8           The slurry sheet 15 flows from the second apron 31 onto a contiguous  
9   first vibrating screen 16. It is sized to retain +4 inch material.

10          The oversize lumps 20 retained by the vibrating screen 16 are delivered  
11   into an impactor 24. The lumps 20 are largely oil sand in composition and  
12   many disintegrate when impacted by the rotating arms of the impactor,  
13   producing comminuted product 27. This product discharges from the outlet of  
14   the impactor onto a second vibrating screen 30. The oversize lumps retained  
15   by screen 30 are discarded. The screened comminuted product, containing  
16   undersize lumps that passed through the screen 16, is discharged into pump  
17   box 18.

18          Pump box 18 is equipped with a vertical shaft agitator 21 that  
19   mechanically agitates the collected screened slurry such that a vortex 22 is  
20   created. The pump box is further equipped with at least one vortex breaker  
21   plate 23 positioned so as to allow the vortex 22 to form at the bottom of the  
22   pump box. Much of the slurry remains in suspension and only the larger lumps  
23   25 (between 2 and 4 inches in diameter) settle to the bottom of the pump box  
24   18. The larger lumps are pumped from a tangential outlet 26 and are delivered  
25   to a third vibrating screen 28 that is sized to retain +2 inch material. The

1    oversize lumps 29 retained by the screen 28 are delivered into the impactor 24.  
2    Most of the oversize lumps are disintegrated when impacted by the rotating  
3    arms of the impactor 24. The comminuted product is discharged into the pump  
4    box 18. Ultimately, the suspended slurry in the pump box is pumped from an  
5    outlet 19 into a pipeline.

6           The foregoing describes our best mode of carrying out the invention.  
7    As will be realized, the invention is capable of other and different  
8    embodiments and its several details are capable of variation, all without  
9    departing from the invention. The scope of the invention is established in the  
10   claims now following.

1       THE EMBODIMENTS OF THE INVENTION IN WHICH AN  
2       EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS  
3       FOLLOWS:

4  
5       1.     A downwardly sequenced assembly for producing an aqueous  
6       slurry of oil sand, ready for introduction into a pipeline, comprising:

7       means for mixing oil sand with water to produce a slurry containing  
8       lumps;

9       means for screening oversize lumps from the slurry to produce a  
10      screened slurry containing undersize lumps suitable for pumping through a  
11      pipeline; and

12      a pump box for receiving the screened slurry, said pump box having  
13      means for mechanically agitating the slurry within the pump box, said pump  
14      box being associated with a means for withdrawing slurry from the pump box  
15      and pumping it into a pipeline.

16

17      2.     The assembly as set forth in claim 1 comprising:

18      an impactor, associated with the screening means, for receiving the  
19      screened oversize lumps, comminuting them to produce comminuted solids  
20      and screening the comminuted solids to reject remaining oversize and pass  
21      solids suitable for pumping through the pipeline; and

22      means for downwardly transferring the screened comminuted solids  
23      into the pump box.

1           3.     The assembly as set forth in claim 2 comprising:  
2           means for recycling a stream of slurry from the base of the pump box,  
3     said stream containing lumps that have reached the bottom of the pump box;  
4           a screening means for processing the recycled slurry to remove  
5     oversize lumps, feeding said oversize lumps to the impactor and returning  
6     screened slurry to the pump box.

7  
8           4.     A process for producing an aqueous slurry of oil sand, suitable  
9     for introduction into a pipeline, comprising:  
10          mixing oil sand and water to form an aqueous slurry containing lumps;  
11          screening the slurry to remove oversize lumps and produce a screened  
12     slurry containing undersize lumps;  
13          temporarily retaining the screened slurry in a pump box for a pre-  
14     determined retention time;  
15          mechanically agitating the slurry contained in the pump box; and  
16          withdrawing slurry from the pump box and pumping it into a pipeline.

17  
18          5.     A process as set forth in claim 4 comprising:  
19          comminuting rejected oversize lumps from the screening step and  
20     screening the comminuted solids to reject residual oversize lumps; and  
21          discharging the comminuted solids into the pump box.



1           6.     A process as set forth in claim 5 comprising:  
2           recycling lumps reaching the bottom of the pump box back to a  
3     screening means;  
4           re-comminuting rejected oversize lumps from the screening means;  
5     and  
6           discharging the re-comminuted product into the pump box.

7  
8           7.     A process for producing an aqueous slurry of oil sand, ready for  
9     introduction into a pipeline, comprising:  
10          dropping the oil sand through the air from the discharge end of a  
11     conveyor onto a downwardly slanted surface spaced below the conveyor  
12     discharge end;  
13          contacting the oil sand with a stream of water as the oil sand moves  
14     through the air between the conveyor discharge end and the surface, to wet  
15     the oil sand;  
16          mixing the oil sand and water as they move together along the surface,  
17     to form a slurry stream;  
18          discharging the slurry stream onto a first screen means and screening  
19     it to reject oversize lumps;  
20          directing the oversize lumps to an impactor, comminuting the oversize  
21     lumps and discharging the comminuted product onto a second screen means  
22     and screening it to reject oversize lumps;  
23          directing the screened slurry into a pump box prior to pumping it into a  
24     pipeline;

1 mechanically agitating the slurry in the pump box by means of a  
2 vertical shaft agitator such that the smaller lumps, sand and bitumen are kept  
3 in suspension but the larger lumps settle to the bottom of the pump box;

4 pumping the larger lumps out of the pump box, delivering the larger  
5 lumps onto a third screen assembly, and screening the lumps to reject  
6 oversize lumps;

7 directing the recycled oversize lumps to an impactor, comminuting the  
8 oversize lumps and discharging the comminuted product back into the  
9 mechanically agitated pump box;

10 pumping the produced slurry out of the mechanically agitated pump  
11 box and into the pipeline.

12

13 8. The process as set forth in claim 4 wherein the retained oversize  
14 lumps are larger than about 4 inches and retention time in the pump box is  
15 sufficient to allow lumps in the size range of about 2 – 4 inches to settle to the  
16 bottom of the pump box while lumps smaller than about 2 inches remain  
17 suspended and are pumped into the pipeline.

18

19 9. The process as set forth in claim 4 wherein the retained oversize  
20 lumps are larger than about 4 inches and retention time in the pump box is  
21 sufficient to allow lumps in the size range of about 2 – 4 inches to settle to the  
22 bottom of the pump box while lumps smaller than about 2 inches remain  
23 suspended and are pumped into the pipeline; and

24 recycling lumps reaching the bottom of the pump box back to a  
25 screening means;

1 re-comminuting rejected oversize lumps from the screening means;  
2 and  
3 discharging the re-comminuted product into the pump box.  
4

5 10. The assembly as set forth in claim 1 wherein:

6 the screening means is adapted to retain oversize lumps greater than  
7 about 4 inches in size; and

8 the pump box and agitation means are selected so as to maintain  
9 lumps smaller than about 2 inches in size in suspension while lumps of about  
10 2 to 4 inches in size settle to the bottom of the pump box.  
11

12 11. The assembly as set forth in claim 10 comprising:

13 an impactor, associated with the screening means, for receiving the  
14 screened oversize lumps, comminuting them to produce comminuted solids  
15 and screening the comminuted solids to reject remaining oversize and pass  
16 solids suitable for pumping through the pipeline; and

17 means for downwardly transferring the screened comminuted solids  
18 into the pump box;

19 means for recycling a stream of slurry from the base of the pump box,  
20 said stream containing lumps that have reached the bottom of the pump box;

21 and

22 a screening means for processing the recycled slurry to remove  
23 oversize lumps, feeding said oversize lumps to the impactor and returning  
24 screened slurry to the pump box.

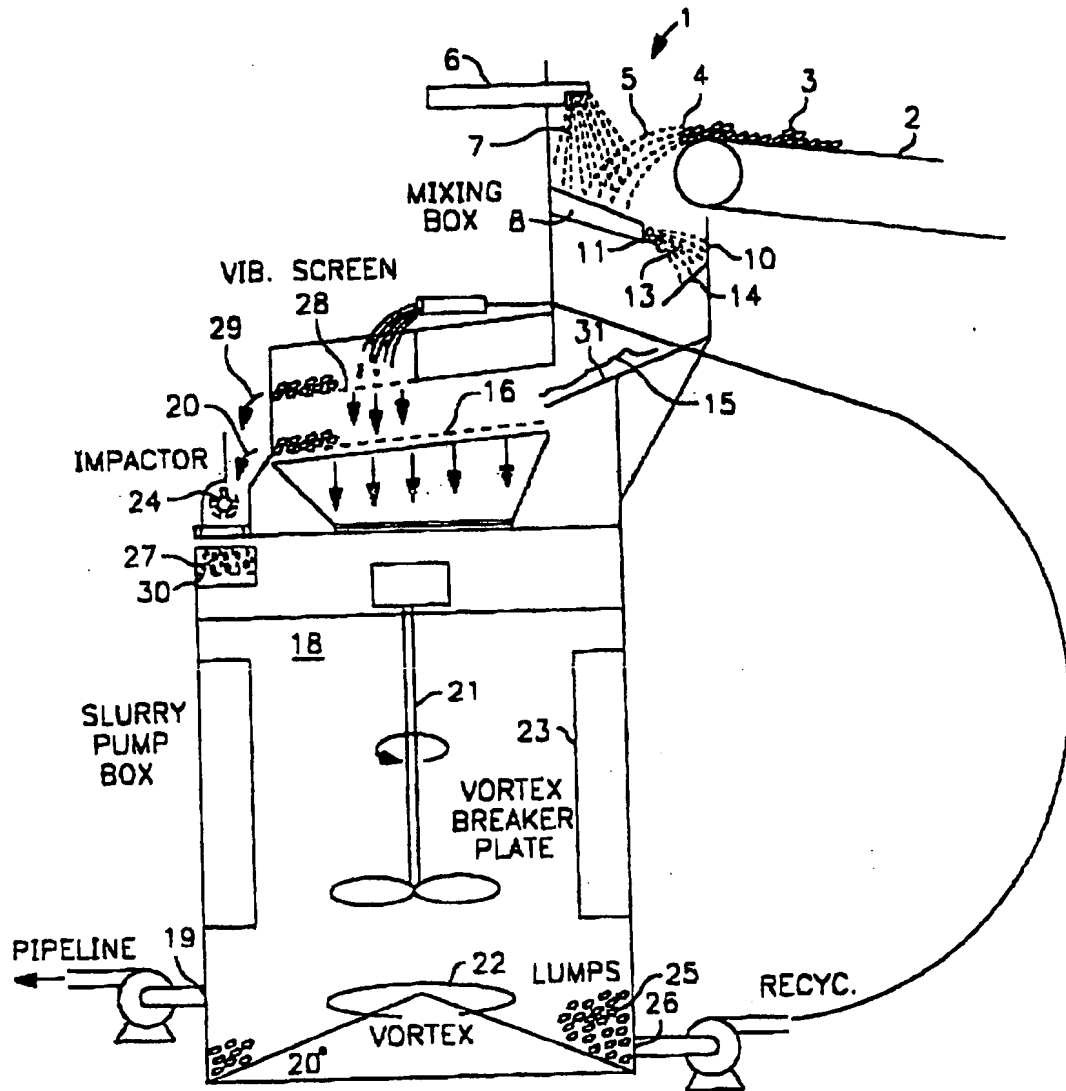


FIG. 1

